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Agricultural biogas plants—A chance for diversification of agriculture in Poland

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ABSTRACT

The aim of the analysis is to present the implementation and development of agricultural biogas plants as a chance for diversification of agriculture in Poland. The main exogenous and endogenous determinants of the development of agriculture biogas plants in Poland were indicated. It is an attempt to present agricultural biogas plants in terms of their spatial distribution as well as the installed capacity and efficiency of agricultural biogas installations. Moreover, the feedstock structure for agricultural biogas production is also analysed.

Contents

1. Introduction

Nowadays, it continues to search for new ways of the agriculture development in Poland. This is also reflected in undertaking a variety economic initiatives using endogenous resources of the agricultural sector. Agricultural biogas plants are some chance for diversification of agriculture and multifunctional development of rural areas. Production and electrical utilization of agricultural biogas (sourced in the process of biomass anaerobic fermentation) is one of the elements of power system based on renewable sources. But, the biogas utilization is economically justified, only if it is carried out simultaneously with the other renewable energy sources utilization [1].

The issue of renewable energy sources utilization as an opportunity for diversification of agriculture and sustainable rural development in Poland is relatively new and rarely undertaken. Considering the structure of the renewable energy sources should be indicated that the most important is biomass and also wind energy [2]. The advantage of biomass is its universality. Moreover, the use of biomass causes to reduce the outflow of capital from various countries and regions [3]. Importance of biomass, mainly energy crops, also related to the role in the diversification of agricultural activities. Thus, it is not surprising that among the renewable energy sources, in 2010, up 85.4% was biomass. In turn, the largest increase in use was recorded for wind energy. In the years 2006–2010 was 6.5-fold increase in acquisition of wind energy in Poland. The wind power is the fastest growing sector of energy technology and is one of the most

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cost-effective renewable energy sources in the world [4]. Besides, the solar energy and heat pumps are becoming popular in Poland, especially in the context of thermal energy.

The process of agricultural biogas plants development is on the initial stage, in Poland. The issue is so important because it is associated with diversification of agricultural production and development of agricultural production for energy purposes. Moreover utilization of agricultural biogas is one of the aspects of multifunctional and sustainable development of agriculture and rural areas. It should be noted that sustainable development is one of the pillars of the development of the European Union. Among the main factors for the agricultural biogas plants development, researchers suggest political aspects, the relevant legal regulations and support for local authorities (exogenous conditionings) [5–7]. On the other hand there are some endogenous conditionings, in the availability of agricultural resources and both technical and financial factors [8].

2. Exogenous and endogenous conditionings of agricultural biogas plants development

The beginnings of agricultural biogas plants in Europe are dated to the middle of 1980s. The first agricultural biogas plants, including small-scale biogas plants ($<150\ kW_e$), were built in Germany, Denmark and Austria. At present, these countries belong to the European leaders in terms of the agricultural biogas plants number [9]. Among other European countries the greatest prospects for the development of agricultural biogas plants Hungary, the Czech Republic and Poland are mentioned [10]. As a way to the development of agriculture and functional diversification the agricultural biogas plants are indicated in Slovakia [11].

Now, more and more attention is paid to the both agricultural diversification and utilization of renewable energy sources. These trends are reflected in various governmental documents as well as in strategic planning. The energy sector development in Poland is conditioned by European Union regulations. Poland, as a member of the European Union is committed to the diversification of energy sources. By 2020, renewable energy should constitute 15% of final energy consumption in Poland. In comparison to other countries of the European Union, it should be: i.e., in Austria—34%, Germany—18% and Czech Republic—13% [12]. In Poland, the Constitution of the Republic of Poland and the Energy Law related to renewable energy and sustainable development. Considering the political aspects it must be noted that the major factor which limits the development of utilization of renewable energy sources and also agricultural biogas plants in Poland is the lack of Renewable Energy Sources Law. As a consequences, in Poland, the development of agricultural biogas plants is at the initial stage. According to the governmental program " Innovative Energy—Energy Agriculture" [13] by 2020 in Poland there are to operate almost 2000 agricultural biogas plants with a total installed capacity of around 2–3000 MW. It is a number similar to the number of rural and urban–rural gminas in Poland—2173 in 2011 [14]. The main exogenous factors conditioning the development of agricultural biogas plants in Poland are the appropriate legal regulations as well as available administrative and financial instruments. Under the Act of 8 January 2010, amending the Act—Energy Law and amending certain other laws [15] with the effect from 1 January 2011, generating agricultural biogas or producing electricity from agricultural biogas is a regulated activity requiring registration of energy enterprises active in the agricultural biogas production. A certain exogenous determinant of the development of agricultural biogas plants in Poland, especially in relation to the small-scale biogas plants ($<150\ kW_e$), is the currently functioning subsidy system based on the European Agricultural Fund for Rural Development (EAFRD). In Poland spending money from the EAFRD is held through the implementation of the Rural Development Program (RDP) for the years 2007–2013. Under this scheme financial assistance is granted to farmers for projects aimed to diversify towards non-agricultural activities, including the agricultural biogas production and energy production from agricultural biogas [16].

Another group of factors affecting the agriculture diversification in Poland, including the implementation and development of agricultural biogas plants, are endogenous factors [3]. They relate to human and financial resources as well as the commercial level of agriculture and the agrarian structure in a given area. The agricultural biogas plants development is determined mainly by the size of farms. This is due to the fact that it is much easier to obtain feedstock for agricultural biogas production from the largest farms.

3. Structure of feedstock for agriculture biogas production

The feedstock for agricultural biogas production is organic material, both from agriculture and industry. The agricultural origin feedstock include: manure, energy crops, waste from plant production, grass clippings, garden waste and leftovers, while industrial origin include waste from the food, dairy, sugar, pharmaceutical, cosmetics, biochemical, paper and meat industries. Taking into account the organic waste the most greatest potential for biogas production is characterised by fat waste (700 m^3 methane production/tone of dry organic matter). Having regard to the dedicated energy crops the grass has the greatest potential for biogas production (5875 m^3 methane production/tone of dry organic matter). Considering the food processing industry should be noted that the glycerine has the greatest potential for biogas production, i.e., 1196 m^3 methane production/tone of dry organic matter [17].

In Poland, as a general rule, first organic waste is used, and only then the dedicated energy crops (that is cultivated specifically for the electricity and/or heat production). In total, in 2011, in Poland about 470,000 t of feedstock were used for agricultural biogas production, of which 73.65% was organic waste, and 26.35% were dedicated crops. The most important source of agricultural biogas is liquid manure (as part of organic waste), which in 2011 accounted for 56.67% of all substrates for agricultural biogas production in Poland; it is followed by maize silage (dedicated crop) – 23.2% and distillery stock – 6.5%. The remaining 13.6% of substrates used included manure, fruits and vegetables remains, potato pulp and cereals (Fig. 1).

Considering the endogenous factors related to the agricultural activity: In 2010, 45% of farms in Poland conducted both plant and animal production, and 37% only plant production, [7] it should be noted that the feedstock potential for agricultural biogas production is much larger. This is also reflected in the governmental document "Trends in the development of agricultural biogas plants in Poland in the years 2010–2020" [18], according to which the available energy potential is 1.7 billion m^3 of agricultural biogas per year. Additionally, in order to obtain substrates for agricultural biogas production, it is expected dedicated energy crops will be introduced in the area of about 700,000 ha.

4. Agricultural biogas plants in Poland—Distribution and structure

In Poland there are 29 agricultural biogas plants (as of 22.11.2012). They are distributed uneven across the country. Most

are located in the following Voivodeships: Pomorskie (6 agricultural biogas plants in: Koczała, Kujanki, Lębork, Pawłówkowo, Płaszczyca and Uniechówek) and Zachodniopomorskie (4 agricultural biogas plants in: Giżyno, Grzmiąca, Nacław and Świelino). 5 of 6 agricultural biogas plants located in the Pomorskie Voivodeship and 3 located in the Zachodniopomorskie Voivodeship (Giżyno, Nacław, Świelino) belong to the same agricultural enterprise (Poldanor S.A.). These agricultural biogas plants were built at pig farms, and their total installed capacity of 7.4 MW makes up 24% of the total installed capacity of all agricultural biogas plants in Poland (Fig. 2).

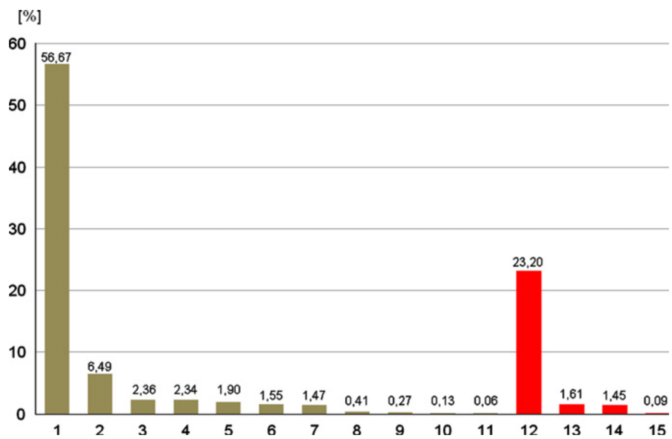


Fig. 1. Feedstock structure for agricultural biogas production in Poland in 2011. Explanation: organic waste: 1—liquid manure, 2—distillery stock, 3—manure, 4—vegetables and fruits remains, 5—lecithin and soaps mix, 6—potato pulp, 7—sugar beetroot pulp, 8—whey, 9—stomach contents, 10—flour, bread and breadcrumbs, 11—fat waste; dedicated energy crops: 12—maize silage, 13—cereal silage, 14—grass silage, 15—lucerne silage.
Source: Developed by the authors based on the data collected from the Agricultural Market Agency (AMA).

Spatial diversity of substrates used for the agricultural biogas production is conditioned by farm size and directions of agricultural production in particular areas of Poland. Considering the distribution of agricultural biogas plants by the basic feedstock for the biogas production it should be noted that the organic waste (liquid manure, distillery stock and other agricultural waste) is a major source of agricultural biogas in western, north-western and northern Poland. It is because high-commercial large farms specialising in livestock production are able to provide an adequate supply of feedstock (mainly liquid manure). The areas with the largest farms (over 15 ha) [7] i.e., the Pomorskie and Zachodniopomorskie Voivodeships, have the largest number of agricultural biogas plants in the country.

The cultivation of dedicated energy crops (primarily maize for silage) are the main source of agricultural biogas produced in eastern, north-eastern and central Poland. In the voivodeships of eastern and central Poland, where small farms (of the average size of about 5 ha) with subsistence profile predominate, there is a small number of agricultural biogas plants. Agricultural biogas production in those parts of Poland is mainly based on the dedicated energy crops, because any agricultural production waste (potential substrates for the agricultural biogas production) are used by the farms themselves.

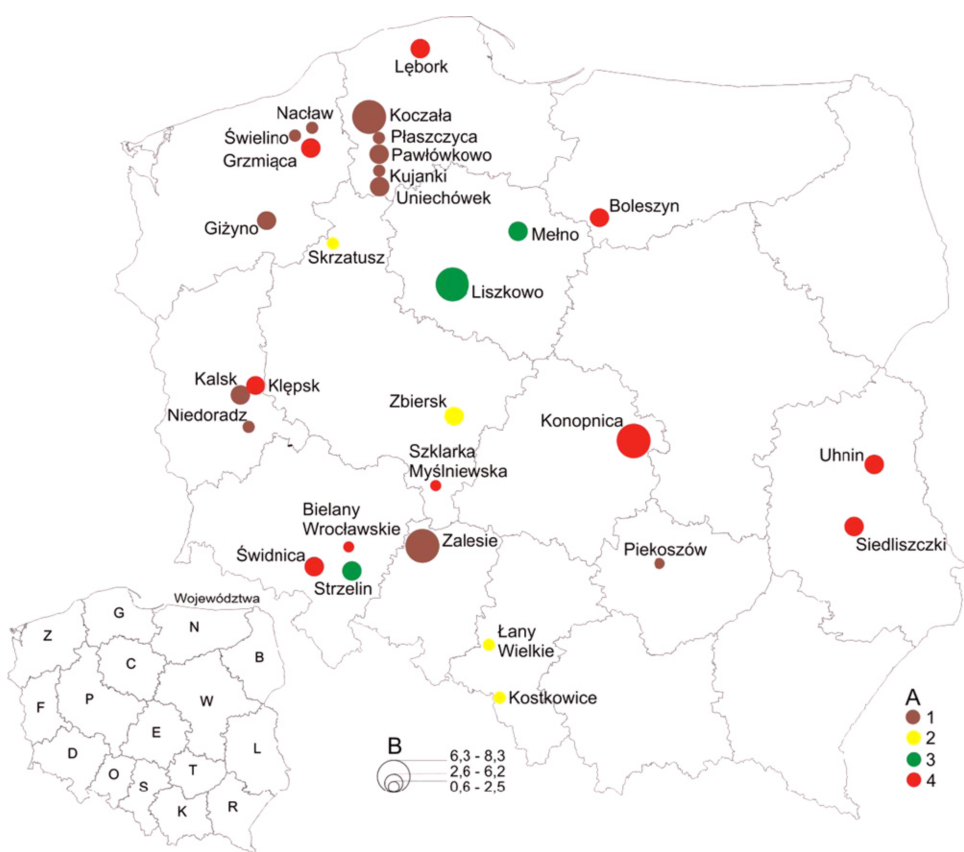


Fig. 2. Agricultural biogas plants distribution in Poland in 2012. Explanation: A—basic feedstock for agricultural biogas production: 1—liquid manure, 2—distillery stock, 3—other agricultural waste, 4—maize silage, B—annual efficiency of the agricultural biogas installations [million m^3/year] Voivodeships: B—Podlaskie; C—Kuiawsko–Pomorskie; D—Dolnośląskie; E—Łódzkie; F—Lubuskie; G—Pomorskie; K—Małopolskie; L—Lubelskie; N—Warmińsko–Mazurskie; O—Opolskie; P—Wielkopolskie; R—Podkarpackie; S—Śląskie; T—Świętokrzyskie; W—Mazowieckie; Z—Zachodniopomorskie.
Source: Developed by the authors based on the data collected from the AMA.

A chance to diversify agriculture of eastern and central Poland in relation to the agricultural biogas plants development is the project financed by the EAFRD connected with the design of small-scale agricultural biogas plants system (<150 kW$_e$). According to the data from the Agency for Restructuring and Modernisation of Agriculture (dated 18.10.2011), 176 farmers from all over Poland have applied for funding small-scale agricultural biogas plants building. The greatest interest in investments related to the agricultural biogas production and electricity from agricultural biogas is expressed by farmers from the Wielkopolskie Voivodeship, from where a third of application comes. A large number of applications has also been sent by farmers from the Kujawsko-Pomorskie, Lubelskie and Mazowieckie Voivodeships. The share of applications for these subsidies submitted in each of these voivodeships is approximately 12% of all applications in Poland. It should be emphasised that the bonus will be given to projects submitted by farmers with small farms located in the areas of unfavourable farming conditions from the gminas with low tax revenues. The farms and gminas with the above mentioned features are located primarily in eastern, south-eastern and central Poland.

5. Energy from agricultural biogas in Poland

Agricultural biogas plants installed in Poland combined heat and power (CHP) generated. The total installed electric capacity is 31,856 MW$_e$ and the thermal capacity—32,953 MW$_t$. Considering the installed capacity of agriculture biogas plants it should be emphasised that both electric and thermal capacity stands at an average of 1 MW. The largest enterprises in this regard can be found in northern Poland in the Pomorskie, Kujawsko–Pomorskie and Warmińsko–Mazurskie Voivodeships. The largest installed electrical capacity (2126 MW$_e$) is found in Liszkowo (Kujawsko–Pomorskie Voivodeship) and Koczała (Pomorskie Voivodeship). The agricultural biogas plant in Koczała has also the largest installed thermal capacity of 2206 MW$_t$ (Fig. 3).

The installed capacity of agricultural biogas plants determines the annual efficiency of the agricultural biogas installations. Considering, therefore, agricultural biogas plants in terms of annual efficiency of the installations it should be mentioned the enterprises division into three main groups: 06–2.5 million m^3/year, 2.6–6.2 million m^3/year and 6.3–8.3 million m^3/year. Agricultural biogas plants in the first group are located in i.a. the Śląskie and Lubuskie Voivodeships. Another group consists of agricultural biogas plants with an annual efficiency of the installations from 2.6 to 6.2 million m^3/year. They occur throughout the country, including the Lubelskie, Warmińsko–Mazurskie and Pomorskie Voivodeships. The third group of agricultural biogas plants, characterised by the highest annual efficiency of the installations (from 6.3 to 8.3 million m^3/year), is located in the Pomorskie and Kujawsko–Pomorskie Voivodeships (Fig. 4).

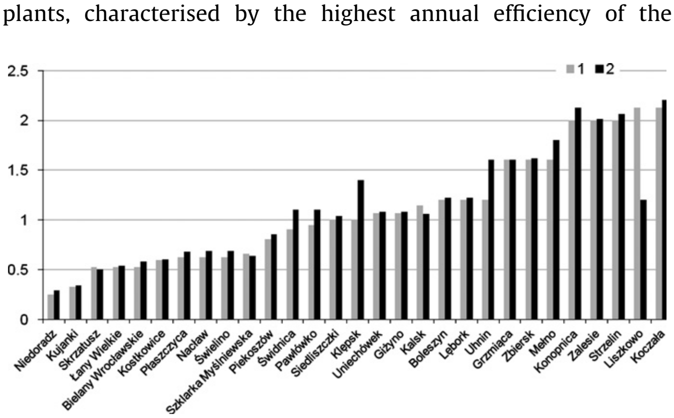


Fig. 3. Installed capacity of agricultural biogas plants in Poland in 2012. Explanation: 1—installed electric capacity MW$_e$, 2—installed thermal capacity MW$_t$. *Source*: Developed by the authors based on the data collected from the AMA.

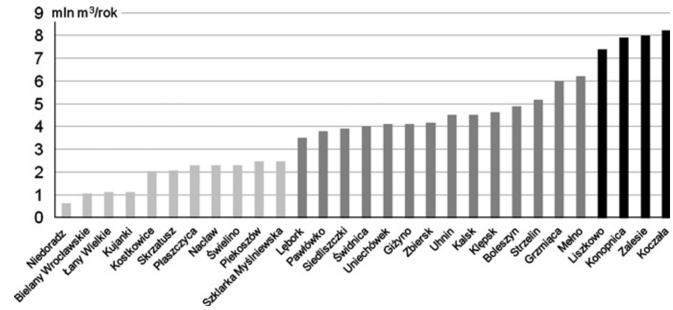


Fig. 4. Annual efficiency of the agricultural biogas installations in Poland in 2012. *Source*: Developed by the authors based on the data collected from the AMA.

In 2011, the agricultural biogas plants in Poland produced 36.64 million m^3 of biogas (however, as already mentioned, the government expertise indicated that in the next few years the annual agricultural biogas production will have reached 1.7 billion m^3). From this agricultural biogas 73.43 GW h of electricity were produced, 73.7% of which (i.e., 54.16 GW h) were introduced to the national power grid. The remaining electricity was used for the production and individual needs of this energy producers. In 2011, electricity produced in agricultural biogas plants accounted for only 0.6% of electricity production from all renewable energy sources, and 0.04% of the total gross electricity production in Poland. At the same time we cannot ignore the importance of agricultural biogas in cogeneration systems. In 2011, as a result of their performance, 88.80 GW h of thermal energy were obtained. It was utilised mainly in the technological processes of these biogas plants, as well as during the implementation of projects directly connected with them, for example for heating of livestock buildings.

6. Conclusions

The end of 2012 there were 29 agricultural biogas plants in Poland operating in the CHP system with an average installed capacity of 1 MW. It should be noted here that 8 of 22 agricultural biogas plants (i.e., 27.6% of the total number of agricultural biogas plants in Poland) belong to the same enterprise that manages pig production. Taking into account all the agricultural biogas plants it can be concluded that they are located mainly in northern and north-western Poland. Given the agricultural biogas plants in terms of feedstock used for agricultural biogas production it must be indicated that there appears a division into the biogas plants based primarily on organic waste (located in western, north-western and northern Poland) and the biogas plants based on dedicated energy crops (located in the eastern and central Poland). The development of agricultural biogas plants in Poland is currently at its preliminary stage. In 2011 electricity from agricultural biogas accounted for only 0.6% of electricity production from all renewable energy sources and for 0.04% of total gross electricity production in the country.

The analysis showed that the development of agricultural biogas plants in Poland is significantly conditioned by exogenous factors, especially infrastructural, legislative and financial ones. Regarding infrastructural conditions it should be mentioned that due to the outdated national electricity grid, there are significant difficulties in connecting the power generators to the main points of supply, and then with the transmission and sale of electricity ("*bottleneck effect*"). In 2011, 73.7% of electricity generated in agricultural biogas plants was introduced into the national power

grid. In addition, the development of agricultural biogas plants is to a large extent conditioned by the possibility of obtaining funding for such activities. In Poland there are currently works under way to develop a system of small-scale agricultural biogas plants functioning at the agricultural farms. The implementation of such projects, namely the emergence of scattered, small power producers, is part of the specificity of Polish agriculture, dominated by small and medium-sized farms (in 2010, 70% of farms were farms whose area did not exceed 5 ha). Given the significant interest of Polish farmers in the development of agricultural biogas plants, as well as the fact that there is a special support from policy makers and financial funds administrators of small subsistence farms owners, it appears that the development of agricultural biogas plants is a real chance for agricultural diversification in Poland (including obtaining additional sources of income) and further multifunctional development of rural areas.

Among the endogenous determinants of the development of agricultural biogas plants in Poland, the most important role is played by the commercial level of agriculture, agricultural activity directions and agrarian structure. In the light of the study it can be stated that both the highest number of agricultural biogas plants and biogas plants of the largest installed capacity are located in the Pomorskie, Zachodniopomorskie and Kujawsko–Pomorskie Voivodeships. These voivodeships are characterised by a relatively large average farm size (about 15 ha) and high-commercial livestock production. These are large farms specialising in animal production which are ideal feedstock suppliers (mainly organic waste) for agricultural biogas production. This is why the aforementioned voivodeships have become the leaders of agricultural biogas production and energy from agricultural biogas in Poland.

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